THE ROYAL AERONAUTICAL SOCIETY

WITH WHICH IS INCORPORATED THE INSTITUTION OF AERONAUTICAL ENGINEERS.

MONTHLY NOTICES,

APRIL, 1942.

Wilbur Wright Memorial Lecture.

The 30th Wilbur Wright Memorial Lecture will be read on Thursday, May 28th, 1942, at 6.30 p.m., by Lieut.-Col. the Rt. Hon. J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., M.P., Vice-President of the Society. The Lecture will be held at the Institution of Mechanical Engineers, Storey's Gate, St. James's, S.W.1 (by kind permission of the Council of the Institution). Light refreshments will be served before the meeting.

Associate Fellowship Examinations.

The next Associate Fellowship Examinations will be held on Tuesday, May 19th, and Wednesday, May 20th, 1942. Full particulars will be sent direct to candidates who have entered for the examination of place and times.

Advertisements.

The fact that goods made of raw materials in short supply, owing to war conditions, are advertised in the Journal should not be taken as an indication that they are necessarily available for export.

Graduates' and Students' Section.

The following programme of meetings has been arranged for the Graduates' and Students' Section to be held in the Library of the Society at 4, Hamilton Place, W.1, at 7 p.m. Senior members of the Society are invited to the lectures and non-members wishing to attend must apply in writing to the Secretary of the Society.

April 29th.—Annual General Meeting of the Graduates' and Students' Section only for the election of Officers and Committee for the coming year and any other business.

May 27.—Lecture by Mr. R. N. Hadwin on " Experimental Vibration Work in Aircraft."

June 17th.—Lecture by Mr. F. H. M. Lloyd, A.F.R.Ae.S., on " The Design of Fighter Aircraft."

Acknowledgments.

The Council acknowledge with thanks the gift of photographs from Mr. S. Camm, C.B.E., Fellow.

Election of Members.

The following members have recently been elected:—

Associate Fellows.—John Allan (from Graduate), Nevil James Ashton (from Graduate), Harry Charles Netterville Barron (from Student), Philip Burton, John Chapman (from Graduate), James Lucas Broome Cordes, Ian Gair Duncas (from Graduate), Donald C. Dundas (from Graduate), Robert W. Harris, Frank Arthur King, Leonard George Morris, John Sinclair, Cyril Woodward Taylor (from Student), Herbert Martin Woodhams.

Associates.—Thomas Barrow (from Student), William Edward Hamilton Dutton (from Student), Francis William Harris, Geoffrey Lewarn, Leonard Charles Mitcham, William Albert Nichols, Arthur Henry Reynolds, Raymond John Shelley, Robert Neville Sjogren (from Graduate), John Charles Ward.

Graduates.—John Taber Appleby, Jack Ball, Dennis Stephen Bancroft (from Student), Ernst Bendit, Bruce John Bleach, Roy William Brown, George Stanley Collett, Ronald Charles Cooper (from Student), Sidney Henry James Freemantle, Norman Geen, Harold Dalton Henniker, Harold George Howell, John Hughes Jones, Sidney Kirkby, George Kenneth More, Hiralal Naranghai Patel, Frank Pawling, William Hatton Sharp, Arthur William Henry Sheppard, Mayavaram Krishnaswami Ranganatham Venkataraman.

Students.—Derek Ellis Ashton, John Charles Digby Cotes, Peter Rivers Doudney, William Ronald Farr, Emlyn George Havard, John Liversidge, Henry Oliver, Gordon Frederick Crighton Rogers, Ian Tongue, Alexander Uydens, Cyril Ward, Mary Theodore Peggy Ward, Donald Charles Whittley, Colin Wilfred Williamson.

Companions.—William Richard Barnes, Richard Christopher Dell, John Robert Gibb, Isaac John Blackwell Jones.

Additions to the Library.

Pamphlets in italics with location reference following in brackets.
Books marked * or ** may not be taken out on loan.

*B.g.111.—*U.S.S.R. Air Fleet (3-View Drawings). By John Stroud. A.T.C. Gazette.* 1942. 6*d.* (PB.5/22.)

**E.b.88.—Theodore von Kármán Anniversary Volume: Applied Mechanics. By Various Authors. California Institute of Technology, Pasadena. 1941. $3.75.

E.b.89.—*The Admittance Method for Obtaining the Natural Frequencies of Systems. By W. J. Duncan. Reprint from Phil. Mag., Series 7, Vol. 32, p. 401. 1941.* (Y.8.a.21.)

E.c.24.—*The Technical Cohesive Strength and Yield Strength of Metals. By D. J. McAdam, Jr. American Institute of Mining and Metallurgical Engineers. (Tech. Pub. 1,414.) 1942.* (PG.1/18.)

J.b.15.—*Report on the Administration of the Meteorological Department, Burma, 1937-41. Govt. Printing Office, Rangoon. 9d.*

L.d.73.—Foundations of Astronomy. By Prof. W. M. Smart. Longmans, Green and Co. 1942. 16/-.

Q.d.51.—*Road Transport—and the National Plan. By Lt.-Col. M. O'Gorman. British Road Federation. 1942.* (PQ.1.b.12.)

**R.b.230.—Wings for Man. By James Armour. (Reprint from 8th Annual Report of the Royal Aeronautical Society.) Printed by Richardson, Greenwich. 1873.

**R.b.231.—The Winged Aerostat. By James Armour. Alexander and Shepheard. 1885.

*S.b.107.—A.B.C. of the R.A.F. (2nd Ed.) Edited by Sir J. Hammerton. Amalgamated Press. 1942. 2/6.

*S.b.108.—The Book of the W.A.A.F. Amalgamated Press. 1942. 1/3. (PS.2/11.)

S.b.109.—The Royal Air Force in the World War. Vol. I (1919-1940). Captain Norman Macmillan. G. G. Harrap. 1942. 10/6.

T.a.97.—*C. H. ("Punch") Dickins. (Biographical Data.) Typescript.* 1942. (Y.5/D.)

*UU.c.—*National Advisory Committee for Aeronautics (U.S.A.): Technical Memoranda.* (1941-42):—

No. 986. The Frictional Resistance Law for Smooth Plates. F. Schultz-Grunow. (From Luftfahrtforschung, Aug., 1940.)

No. 987. Factors Influencing the Fatigue Strength of Materials. F. Bollenrath. (From Luftfahrtforschung, October, 1940.)

No. 988. Observations of the Effect of Wing Appendages and Flaps on the Spread of Separation of Flow over the Wing. G. Hartwig. (From Luftfahrtforschung, March, 1940.)

No. 989. Buckling Tests of Eccentrically Loaded Beam Columns. J. Cassens. (From Luftfahrtforschung, October, 1940.)

No. 990. Contribution to the Aerodynamics of Rotating-Wing Aircraft. G. Sissingh. (From Luftfahrtforschung, July, 1940.)

No. 991. The Oscillating Wing with Aerodynamically Balanced Elevator. H. G. Küssner and I. Schwarz. (From Luftfahrtforschung, Dec., 1940.)

No. 992. Statistical Analysis of the Time and Fatigue Strength of Aircraft Wing Structures. H. W. Keul. (From Jahrbuch der deutschen Luftfahrtforschung, 1938.)

No. 993. Direct Injection in Internal-Combustion Engines. J. E. Tuscher. (Ministère de l'Air: P.S.T. No. 89, 1939.)

No. 994. Effect of Threaded and Serrated Holes on the Limited Time and Fatigue Strength of Flat Light-Alloy Strips. H. Bürnheim. (from Luftfahrtforschung, March, 1941.)

No. 995. The Creep of Laminated Synthetic Resin Plastics. H. Perkuhn. (from Luftfahrtforschung, Feb., 1941.)

No. 996. Two-Dimensional Potential Flow Past a Smooth Wall with Partly Constant Curvature. W. von Koppenfels. (From Luftfahrtforschung, July, 1940.)

No. 997. Determination of the Bending and Buckling Effect in the Stress Analysis of Shell Structures Accessible from One Side only. A. Dose. (From Luftfahrtforschung, March, 1941.)

No. 998. Inertia of Dynamic Pressure Arrays. H. Weidemann. (From Luftfahrtforschung, July, 1940.)

No. 999. Stress Analysis of Circular Frames. H. Fahlbusch and W. Wagner. (From Luftfahrtforschung, April, 1941.)

No. 1000. The Temperature of Unheated Bodies in a High-Speed Gas Stream. E. Eckert and W. Weiss. (Forschung, Jan.-Feb., 1941.)

No. 1002. Contribution to the Ideal Efficiency of Screw Propellers. W. Hoff. (From Luftfahrtforschung, April, 1941.)

No. 1003. The Resistance Coefficient of Commercial Round Wire Grids. B. Eckert and F. Pflüger. (From Luftfahrtforschung, April, 1941.)

No. 1004. Statics of Circular-Ring Stiffeners for Monocoque Fuselages. W. Stieda. (From Luftfahrtforschung, June, 1941.)

WB.21.—Journal and Proceedings of the Royal Society of New South Wales: Vol. LXXV, Part 2, 1941.

V.13/2.—*Society of Aeronautical Weight Engineers (U.S.A.). Year-Book*, 1942 (*Vol.* 2, *No.* 1). (Y.34.)

*X.c.B.22.—Glossary of Aeronautical Terms. (2nd Ed.) Douglas H. Nelson. George Newnes, Ltd. 1941.

*Y.19.—*Ministry of Aircraft Production: D.T.D. Specifications.* Nos. 44D, 65A, 67A, 87A, 150A, 188A, 204A, 222, 279A, 336B, 337A, 344A, 402A, 419, 420A, 439, 446, 451, 452, 453, 454, 459, 461, 464, 469, 470, 471, 474, 478, 479, 481, 483, 486, 487, 489, 490, 491, 493, 494, 496, 497, 499, 500, 510, 513, 520, 522, 545, 911, 913, 914A.

Y.24.—*Tin Research Institute: Publications.*

No. 108. Surface Hardness of Metals. Bruce Chalmers. 1941.

J. Laurence Pritchard, *Secretary and Editor.*

THE EFFECT OF A HIGH SPEED DIVE ON THE AIRCRAFT POWER PLANT.*

(*Luftwissen, Vol.* 8, *No.* 8, *August*, 1941, *pp.* 246-250.)

Translated by L. J. BAKER.

The introduction of German " Stukas " has been one of the great surprises of the present war. By means of this weapon, daring men, with the true fighting spirit, have already obtained innumerable successes of the greatest importance on all fronts. These results could not have been achieved but for the conviction that German scientists and engineers had so perfected the design of this dive-bomber that it could withstand the exceptional demands made on it—especially on the engine and airscrew.

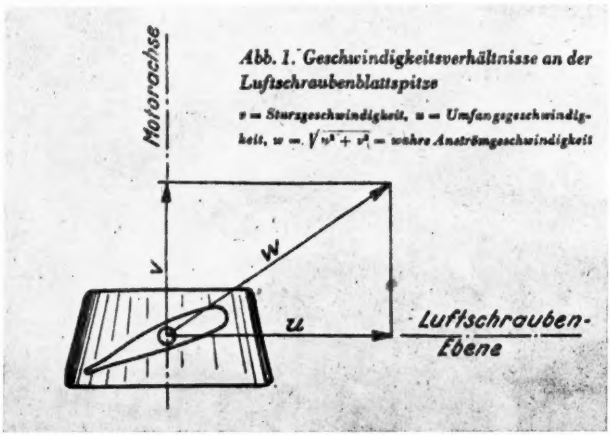

FIG. 1.

Speed relations at the airscrew blade tip.
v = diving speed; u = peripheral speed;
$w = \sqrt{(u^2 + v^2)}$ = true velocity of incident flow.
Luftschraubenebene = airscrew plane.

The *noise of the high speed dive* rending the air with ear-splitting screams is in itself enough to make us realise the terrific strain on the driving gear. This sound is due chiefly to the airscrew on which the speed of the incident air over certain regions exceeds that of sound when the diving speed and engine r.p.m. are increased sufficiently. The effect is favoured by the fact that even in horizontal high speed flight, the present highly-loaded airscrews work with their blade-tip speed comparatively close to the velocity of sound. Fig. 1 shows how

* Published by permission of the Ministry of Aircraft Production, R.T.P.

TABLE I.

EFFECTS OF A HIGH-SPEED DIVE ACTING ON THE POWER PLANT.

FACTOR.	EFFECT.	COUNTER MEASURES.
High speed in the dive	*a*. Airscrew acted on by the relative wind drives the engine (closed throttle) at excess r.p.m. This results in increased stress on engine and oirscrew owing to inertia forces.	The use of variable pitch airscrews.
	b. The high relative wind causes super-cooling in the water and oil circuits since the heat given out by the engine is only slight.	Close the radiator shutters.
Closed throttle with high engine r.p.m. during high speed dive	Great depression in the cylinders and slight combustion, causing oiling-up of the combustion chamber and impairing the ignition.	A combustion chamber of a special design and protected position of the sparking plugs.
Flattening-out at great speed at the smallest possible radius	Action of a gyroscopic moment on the airscrew, causing additional stress on screw shaft and mounting.	Use of high diving brakes and variable pitch screw to check diving speed and reduced engine r.p.m. depending on the flattening-out radius.
Continuous steep position of aircraft during high speed dive	The working of the feed and vent pipe of the fuel systems are impaired.	Special arrangement of the suction and vent connections. Use of special automatic vents.
Rapid and large changes of altitude in the high speed dive or climb.	Increased strain on the working of the control apparatus and the durability of their aneroid controls.	Improved materials and method of construction for aneriod controls.

the true speed w of the air incident on the blade-tip of an airscrew is the resultant of peripheral velocity u and diving speed v.

The crew of the aeroplane hear much less of these noises than the observer on the ground because—especially with high engine r.p.m. a strong directional effect of sound occurs in the direction of the airscrew plane.

Effect of the High Speed Dive on the Driving Gear.

During a dive, both airscrew and power plant are subjected to special effects mainly due to the high speed and consistently steep inclination of the aircraft. Even in stunt flying the power plant is not affected to such an extent nor are the effects as marked. Table I reproduces a brief summary of the most important of these influences and the counter-measures adopted. Further particulars on

Abb. 2. Sturzkampfflugzeug Ju 87 mit Motor Jumo 211 beim Sturz

Fig. 2.

this subject will be given in connection with the illustrations covering the liquid-cooled 12-cylinder two-bank V engine Jumo 211 (Fig. 3). All the dive-bombers Ju. 87 and Ju. 88 most commonly used in the Luftwaffe are fitted exclusively with this well-tried high-duty power injection engine.[1]

[1] The American and British dive-bombers which so far have become known to us are nearly all designed as ship-borne aircraft. Unlike the German dive-bomber, they are fitted without exception with air-cooled engines. See also "Sturzbomber," in Wehrtechnische Monatshefte, Vol. 45 (1941), No. 3, page 54.

EFFECT OF DIVING SPEED.

ENGINE R.P.M.

Even the first dive-bombers—the " Helldivers," constructed in America at the time when Germany was debarred from any form of military aviation, possessed a comparatively high diving speed although the design of the airframe was still aerodynamically unfavourable. This led to considerable excess r.p.m. in the engines which were fitted with rigid airscrews. As the airframe underwent progressive aerodynamic improvements, the diving speeds and, consequently, the excess r.p.m. speeds in later designs were so greatly increased that in addition to the distressing noises, the great inertia forces gave rise to extremely difficult

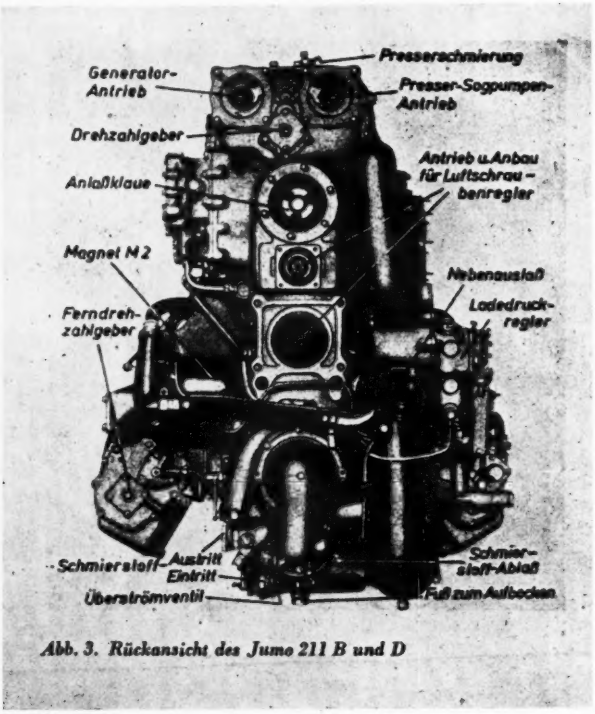

Abb. 3. Rückansicht des Jumo 211 B und D

FIG. 3.

Rear view of Jumo 211 B and D.

Letterpress.

L.H.S. (starting at top):—

Generator drive.
To rev. counter.
Starter dog clutch.
Magneto M_2.
To distant reading rev. counter.
Lubricating oil exit.
,, ,, inlet.
Overflow valve.

R.H.S. (starting at top):—

Lubrication for air compressor; drive for compressor and suction pump; drive and fitting for airscrew governor.

By pass.
Boost regulator.
Oil drain.
Foot-rest for lifting engine.

strength problems for the engine and airscrew. These difficulties also occurred in Hs. 123 fitted with rigid airscrew. This design was the first successful German dive-bomber.

A first attempt was made—(in aircraft in which the diving speed was not high)—to find a remedy in the full-throttle power dive whereby the inertia forces in the engine were, in a great measure, balanced by the gas forces. This resulted in high excess r.p.m. amounting to about 30 per cent. which soon called for a better solution. Since in a high speed dive, the engine with closed throttle, races violently owing to the action of the airflow on the airscrew—(similar to the so-called " windmilling " effect)—and the available resistance torque is very small, an alteration of the blade-setting angle of the airscrew appeared to be the best method of keeping the engine r.p.m. within reasonable limits during a dive. By using adjustable pitch screws and setting the blades to a large pitch, it was then possible to avoid exceeding the working r.p.m. ranges even during the most rapid dives.

Diving Speeds.

Thus, by limiting the engine r.p.m. the direct over-stressing of the driving-gear was eliminated, but at the cost of a further increase in the driving speed because the braking effect of the engine (depending on a conversion of the kinetic energy of drop of the power plant), had been greatly reduced. Under these conditions, for instance, according to reports of the Curtiss Propeller Division, 1939—the fantastic terminal velocity of about 925 km./hr. (575 m./h.), was actually reached after a dive of about 900 m. at an engine speed of 2,550 r.p.m. with the Curtiss-Hawk 75, a low-wing aircraft with retractable undercarriage, and automatic V.P. airscrew. This record diving speed which is said to have been raised to about 1,000 km./hr. in 1940, is not surprising for an aerodynamically excellent airframe of to-day, since the propelling force in a dive is almost equal to the full flying weight, that is to say, about six times greater than the maximum value in the horizontal high speed flight. For purely tactical reasons alone, however, employment of such speeds is useless.

Flattening-out and Dive Brake.

The greater the diving speeds, the greater must be the radius of the flattening-out curve if the centripetal acceleration is to remain below the value 5g which the human body can still withstand for a short time.[2] The minimum altitude for flattening-out becomes so great in the case of high diving speeds, that the accuracy of bomb-aiming is impaired beyond all limits. The important point is, therefore, to limit the diving speed to a value which in all cases, will assure accuracy of aim and safe flattening-out at low altitude.

With this end in view, the Ju. 87 and the Ju. 88, were fitted with diving brakes which, as we know, have already proved indispensable on high performance sailplanes.[3] In the Ju. 87, the brake consists of narrow metal strips placed under the two wings. These strips have a very small resistance when in the position of rest (closed). When spread out, however, they place themselves vertically to the direction of dive. In this position and in spite of their amazingly small surface, they generate in the rapid air flow, a braking effect whereby the greatest diving speed can be reduced by approximately 25 per cent.[4] At the same time a flattening-out device with push-button release was installed by means of which the flattening-out operation starts automatically at the instant

[2] See S. Ruff: " Die physiolog. Wirkung hoh. Beschleunigungen." (The physiological effect of high acceleration.) Luftwissen, Vol. 7 (1940), No. 2, page 24.

[3] E. Foku, 410109: " Sturzflugbremsen im Segelflugzeug." (High speed diving brakes on sailplanes.) Luftwissen, Vol. 8 (1941), No. 1, page 29.

[4] " Die Sturzflugbremse." (High speed diving brakes.) See Junkers Nachrichten, Vol. 11 (1940), page 230, as well as H. Wenke: " Der Sturzbomberwurf." (Dive-bombing.) Luftwissen, Vol. 8 (1940), No. 4, page 117, Fig. 4.

the bomb is dropped, and is completed at a constant radius, so that the pilot can concentrate all his attention on the target.

Gyroscopic Moments of the Airscrew.

When flattening-out after the dive, gyroscopic moments occur in the airscrew and produce additional stresses on airscrew, airscrew shaft and mounting.[5] The magnitude of these moments is dependent, on the one hand, on the angular velocity of the flattening-out process, that is to say, on the diving speed and flattening-out radius, and on the other, on the engine r.p.m. Since, as already stated, the first of these characteristics is fixed by tactical consideration, the maximum permissible engine speed r.p.m. is determined solely by the additional stresses due to the gyroscopic moments. When fixing the r.p.m. the maximum permissible value should be aimed at because full advantage must be taken of the engine braking effect when diving—in the same way as with the engine of a transport vehicle travelling downhill.

Variable Pitch Airscrews.

By using simultaneously variable pitch airscrews and diving brakes, all necessary adjustments of diving speed and engine r.p.m. can be made in the Ju. 87 and Ju. 88. For this purpose electrically operated variable pitch V.I.M. airscrews with manual control are used, or else Junkers V.S. variable pitch airscrews with automatic governors (Fig. 3, control installation). In the latter case, the governor carries out the continuous alteration of the airscrew pitch so as to maintain the predetermined engine r.p.m. throughout the whole course of the dive.

Whereas so far, we have dealt solely with the influences of the diving speed on the *strength* of the diving gear, we will now give some explanations on the essential influences of the dive on the *working behaviour* of the engine. We shall deal, in particular, with influences which must be under strict control since the reliable working of the engine depends on them in the most critical phase of the dive, that is to say, shortly after flattening-out, when the engine load is changed from running-light to maximum performance so that the aeroplane can escape from concentrated anti-aircraft fire by an accelerated climb.

Cooling Effect During High Speed Dive.

The cooling effect of the relative wind reaches its peak during the dive. As, however, owing to the engine running light, the amount of heat to be evacuated is very slight there is a risk of the lubricating oil and engine coolant becoming too cold thus interfering with the full load working immediately following on to the dive. The regulator flaps of the coolers concerned must, therefore, be closed and hermetically sealed before starting the dive.

Effect of the Closed Throttle.

The essential condition that the throttle must be closed during a high speed dive results in a comparatively high suction pressure in the cylinder of the engine turning at a high r.p.m. The motor will vary directly as the diving velocity and a considerable quantity of oil is sucked from the piston bearing surface into the combustion chamber (Fig. 4). As the combustion is practically negligible, this oil collects and escapes through the exhaust pipes. This phenomenon as such is not to be considered as dangerous to the engine during a dive. At the same time greater demands must however be made on the sparking plugs which in spite of oiling up during the dive, must on no account cause miss-fires when changing over to the subsequent full-load climb. This danger can be avoided

[5] See G. Bock: "Die Kreiselmomente der Luftschraube." (The Gyroscopic moments of the airscrew.) Luftwissen, Vol. 8 (1941), No. 3, page 96 (R.T.P. Translation No. 1333).

by a suitable shape of the combustion chamber with specially protected positions of the sparking plugs.

Fig. 4 gives a very clear idea of the path of the induction air in the Jumo 211. The air passes the inlet in the dynamic scoop through the suction pipe and a system of guide-vanes into the centrifugal supercharger where both its pressure and speed are increased. The air then passes through the throttle (which is under automatic boost control), and enters an expanding diffusor in which a part of the kinetic energy is converted into pressure. Induction pipes lead from the diffusor to each cylinder bank. It will be noted that these leads are

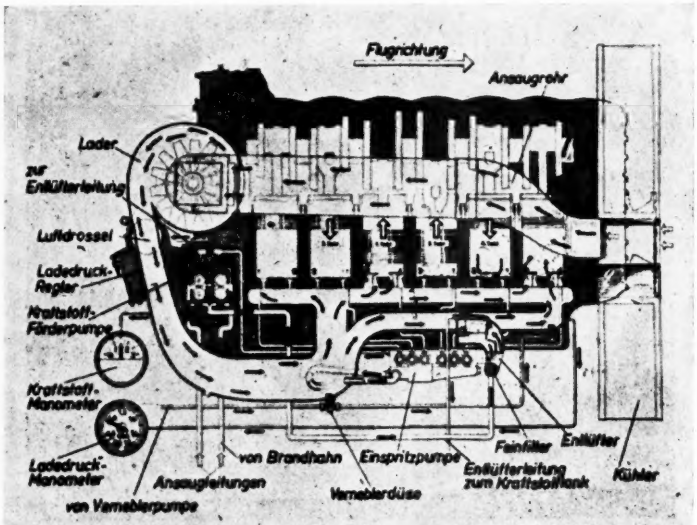

Abb. 4. Ladeluft- und Kraftstoffversorgung des Jumo 211 B und D

FIG. 4.

Induction air and fuel supply of the Jumo 211 B and D.
Flugrichtung=direction of flight.
Ansaugrohr=suction tube.
Lader=blower.
Zur Entlüfterleitung=to vent.
Luftdrossel=air throttle.
Ladedruckregler=boost regulator.
Kraftstoff-Förderpumpe=fuel delivery pump.
Kraftstoff Manometer=fuel pressure gauge.
Ladedruck Manometer=boost gauge.
Von Verneblerpumps=from atomiser pump (starting).
Ansaugeleitungen=suction pipes.
Von Brandhahn=from main fuel cock in fireproof bulkhead.
Verneblerdüse=atomiser nozzle.
Einspritzpumpe=injection pump.
Feinfilter=fine filter.
Entlüfterleitung zum Kraftstofftank=vent pipe to fuel tank.
Enttlufer=vent.
Kühler=radiator.

further sub-divided to ensure a uniform distribution of the air charge to the individual cylinders.

INFLUENCE OF POSITION IN THE HIGH-SPEED DIVE.

A high-speed dive at an angle of 70° to 80° from a great height terminating after several stages within a few hundred metres of the target, frequently takes 30 sec. The position, with almost vertical longitudinal axis (Fig. 2) which the engine must occupy during the dive is therefore incomparably more pronounced

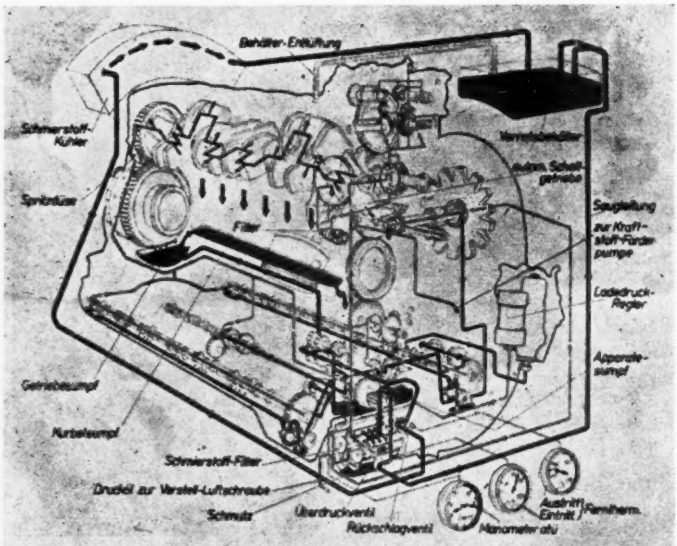

Abb. 5. Schema des Schmierstoffkreislaufs des Jumo 211 B und D

FIG. 5

Diagram of the oil of the Jumo 211 B and D system.
Behälter-Entluftung = tank vent.
Schmierstoff-Kuhler = lubricating oil radiator.
Vorratsbehälter = storage tank.
Autom. Schaltgetriebe = automatic gear change for blower.
Saugleitung = induction pipe.
Spritzdüse = spray nozzle.
Zur Kraftstoff Förderpumpe = to the fuel feed pump.
Getriebesumpf = gear sump.
Kurbelsumpf = crank sump.
Ladedruckregler = boost regulator.
Apparatesumpf = auxiliary drive sump.
Schmierstoff-Filter = lubricating oil filter.
Austritt / Eintritt } Ferntherm. = outlet / inlet } = distant reading thermometer.
Manometer = manometer.
Drucköl zer Verstell-Luftschraube = pressure oil for variable pitch airscrew.
Schmutz = dirt.
Uberdrückventil = pressure release valve.
Rückschlagventil = non-return valve.

than in acrobatic manœuvres in which the effect is, generally speaking, of much shorter duration and also considerably weakened by the centrifugal forces. Above all the performance of the fuel installation is affected. It is absolutely essential for the performance of the plant that the suction and ventilation leads should be connected with the storage tank in such a way that the supply is always assured not only in the high-speed dive, but especially in the subsequent climb, and that in all positions, *one* ventilation lead is always clear. Other counter measures will now be explained individually.

FUEL SUPPLY.

Thorough ventilation is of special importance in ensuring an uninterrupted supply of fuel. The diagram of the fuel path (Fig. 4) shows how this condition is obtained in the Jumo 211. Starting from the main cock in the fireproof

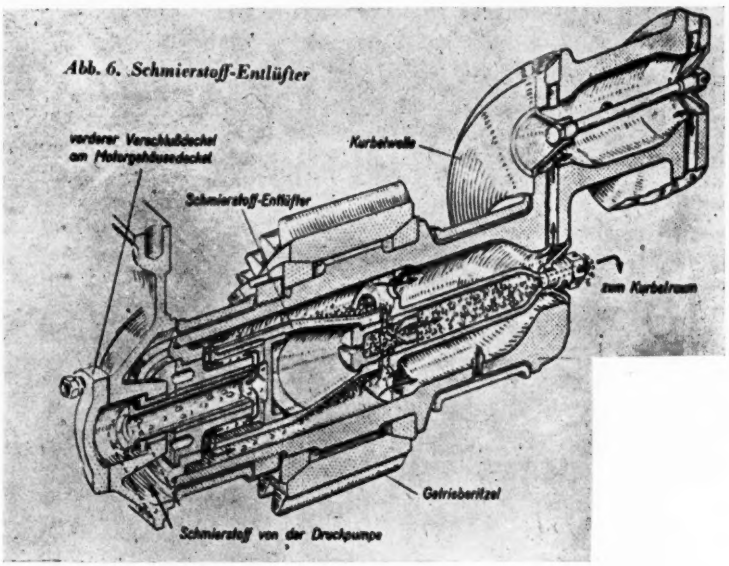

FIG. 6.

Air vent in crankshaft lubricating system.

Vorderer Verschlussdeckel am Motorgehausedeckel=front cover plate on the engine crankcase.
Kurbelwelle=crankshaft.
Schmierstoff Enthufter=lubricating oil air vent.
Getrieberitzel=driving pinion.
Schmierstoff von der Druckepumpe=lubricating oil from pressure pump.

bulkhead, two suction leads run to the duplex fuel delivery pump and from this point a common pressure lead runs via a fine filter and a float controlled deaereator (vent) to the injection fuel pump. A lead connects the float controlled vent directly to the fuel tank. The vent of the fuel delivery pump is also connected to this lead. Close by is the connection of the atomiser pump which sprays atomised fuel through nozzles into the induction lead at two points so as to simplify starting.

ENGINE COOLING FLUID CIRCUIT.

During the high-speed dive, the engine coolant circuit must always be sufficiently full so that no break (vapour lock) of the flow can occur in any position whatsoever. In order to reduce the cooling resistance, modern cooling installations are frequently of the closed circuit excess pressure type.[6] With such an installation, the danger of a discontinuity (vapour lock) in the lock is reduced.

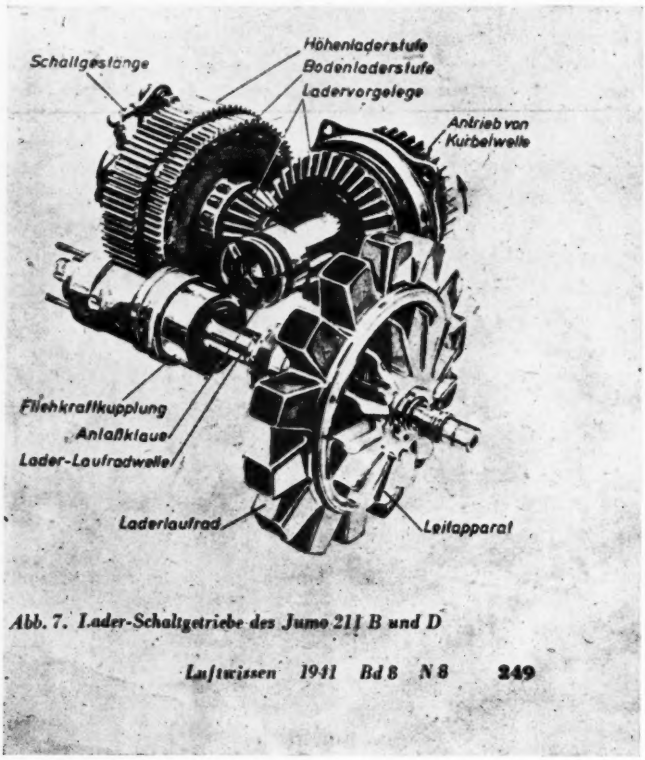

FIG. 7.

Blower change speed gear of the Jumo 211 B and D.

Schaltgestänge = gear lever.
Hohenladerstufe = (high speed gear for altitude).
Bodenladerstufe = low speed gear for ground.
Ladervorgelege = lay shaft.
Antrieb von Kurbelwelle = crankshaft drive.
Fliekraftkupplung = centrifugal coupling.
Anlassklaue = dog clutch for starter.
Lader-Laufradwelle = blower rotor wheel shaft.
Laderlaufrad = blower rotor wheel.
Leitapparat = inlet vanes (rotary).

[6] See H. Carosseli: "Uberdrück Kühlung für Flugmotoren." (Pressure cooling for aircraft engines.) Luftwissen, Vol. 7 (1940), No. 11, page 373.

LUBRICATING OIL SYSTEM.

The lubricating oil system is most seriously affected by the position of the aircraft and is diagrammatically reproduced in Fig. 5. The storage tank is connected by a suction lead with the pressure pump which delivers the lubricating oil to the lubricating points via a slot (streamline) filter (grey lines). The return lubricant (black lines) collects, in front, in the gear box sump and, at the rear, in the auxiliary drive sump. From each of these two reservoirs (which also drain the return from the crankcase sump), the lubricant is evacuated by means of a suction pump to the radiator and finally returned to the storage tank.

During the high speed dive the return lubricating oil collects chiefly in the front sump and, during the climb, in the rear sump. The two suction pumps must, therefore, be designed so that they can safely carry the quantity of lubricant distributed in this way. During a dive the pump occupying the topmost position, however, delivers almost entirely pure air which reaches the storage tank from which the greater part is exhausted through the tank vent (directly into the crankcase (Fig. 5).

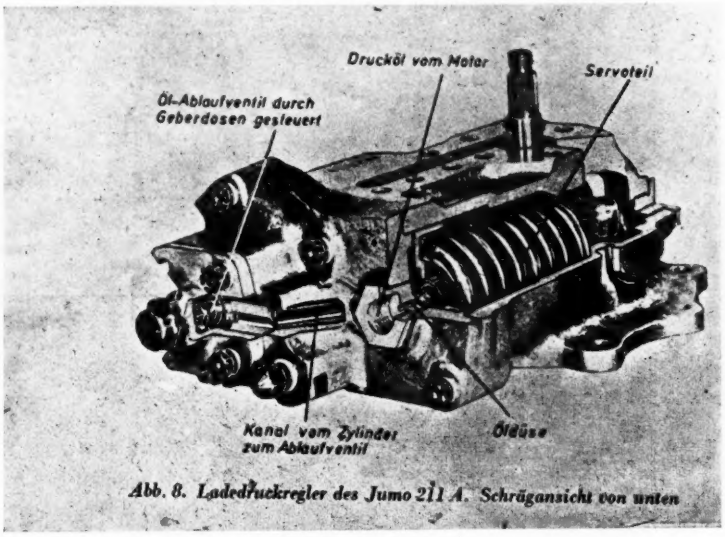
Drucköl vom Motor
Servoteil
Öl-Ablaufventil durch Geberdosen gesteuert
Kanal vom Zylinder zum Ablaufventil
Öldüse
Abb. 8. Ladedruckregler des Jumo 211 A. Schrägansicht von unten

FIG. 8.

Mixture pressure regulator (boost control) of the Jumo 211 A (seen at an angle from below).

Druköl vom Motor = pressure oil from engine.

Ol-Ablaufventil durch Geberdosen gesteuert = oil drain valve controlled through aneroid.

Servoteil = servo part.

Kanal vom Zylinder zum Ablaufventil = channel running from the cylinder to the drain valve.

Oldüse = oil nozzle.

Care must be taken, however, to prevent any air bubbles which may still be in the lubricating oil from penetrating into the crankshaft bearing, as experience has proved that bearing surfaces which have become heated during operation, are liable to be seriously damaged by corrosion. For this reason, a special vent (Fig. 6) is installed in front of the lubricant inlet on the shaft. The vent operates

on a centrifugal principle, the heavy lubricating oil being forced outwards into an expanding ring chamber from which it passes to the bearing while the lighter air bubbles collect about the axis of rotation and pass into the crankcase.

Effect of Rapid Changes of Altitude.

The great and rapid changes of height connected with every high speed dive, are accompanied by an abrupt change in the atmospheric pressure and temperature of the air, with the result that a great strain is imposed on the durability of the barometric aneroids of the various control gears. The quality of these highly sensitive instruments is proved by the fact that they work perfectly in spite of the increased stress and only very rarely give any trouble. A brief description of two of these instruments will now be given.

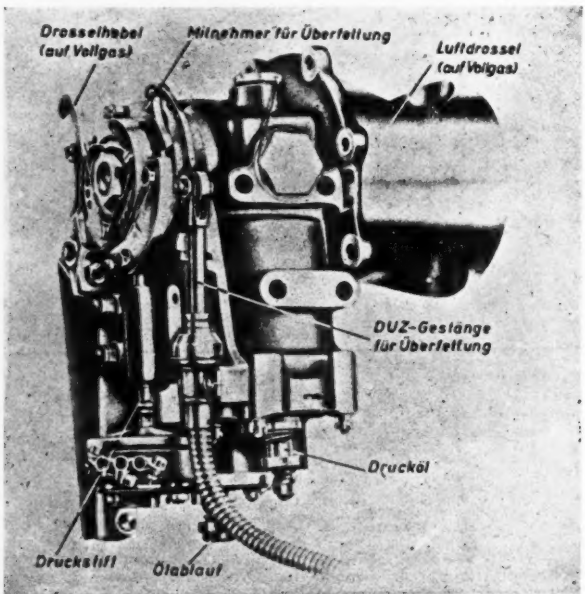

Abb. 9. Zusammenbau von Ladedruckregler und Luftdrossel des Jumo 211 B und D

Fig. 9.

Assembly of the mixture pressure regulator and air throttle of the Jumo 211 B and D.

Drosselhebel (auf Vollgas)=throttle lever (wide open position).
Mitnehmer für Überfettung=follower for richening mixture (interlock).
Luftdrossel (auf Vollgas)=air throttle (wide open position).
D.U.Z.-Gestänge für Überfettung=D.U.Z. control rod for richening mixture.
Drückstift=pressure pin.
Drücköl=pressure oil.
Olablauf=oil drain.

Automatic Blower Speed Changing Gear.

The Jumo 211 has a single-stage blower with two-speed gear. The latter is reproduced in Fig. 7. It is driven from the crankshaft via a bevel gear and lay shaft. This shaft has a free-wheel coupling and a disc coupling actuated by the change-speed lever so that, according to the gear lever position, the blower rotor shaft can be operated either via the small or the large ratio of a spur gear train which is permanently in mesh. The change-over from a lower blower speed at the ground to a higher speed at altitude, is automatically effected, according to the height of flight, by means of a barometrically controlled switch.

In the Jumo 211, the change-over altitude is set at about 2,500 m., consequently the blower speed r.p.m. is also automatically changed in the high-speed dive at this altitude. A specially important protection is also provided by a centrifugal coupling (Fig. 7). Independently of the altitude of flight, this coupling prevents all over-stressing of the blower rotor in the case of excess r.p.m. during the dive by switching over automatically to a low blower r.p.m. It will be seen in Fig. 7 that the rotor is of the " box " type of wheel characteristic of the Junkers, and has separate rotating intake vanes (rotary diffusor). This " closed " wheel form of rotor is certainly somewhat more expensive and takes more time to manufacture than the more commonly used semi-shrouded wheels; on the other hand, it has amongst other advantages, a slightly greater efficiency and a simple axial balance of end thrust.[7]

Induction Pressure Regulator (Boost Control).

The induction pressure regulator whose control box is also exposed to abrupt changes in the air density during the high speed dive, consists (Fig. 8), as usual, of a transmitting part and an amplified or servo-part. Pressure oil penetrates into the lower part of the latter through a narrow nozzle and displaces a spring-loaded working piston which in its turn moves the air throttle via a suitable gearing. The oil pressure and consequently the position of the working piston are determined by means of a drain-valve in the transmitter. This valve in its turn is controlled by an aneroid which is under induction pressure and connected by a channel with the working cylinder (servo).

Fig. 9 reproduces the organic structure of the regulator and the air throttle which is designed as a rotary slide valve. Figs. 3 and 4 show the connection with the induction leads of the engine.

Questions Concerning Operation.

The dive-bomber pilot is, of course, expected to possess the highest qualifications, flying efficiency as well as a capacity for reacting rapidly in all circumstances. In addition to attending to his aeroplane and its armament, he must carry out the following operations, before starting the dive:—

—closing oil and water radiator,
—setting airscrew for large pitch,
—closing throttle of engine,
—putting on high speed dive brakes,
—adjusting the trim of the aircraft.

Immediately after flattening-out, *i.e.*, during a critical stage of the attack and whilst still under the influence of the physiological after-effects of flattening-out, he must

[7] See W. v.d. Null: " Uberlegungen zur Frage d. grosstmogl. Forderhohe einstuf. Radial-Lader an Flugmotoren." (Considerations on the question of the maximum delivery head of single stage radial blowers for aircraft engines.) Luftwissen, Vol. 7 (1940), No. 5, page 174.

—close the high speed dive brakes,
—alter the trim,
—re-open the radiator,
—set the airscrew for small pitch for climb, and
—open the throttle steadily until full load is reached.

Thus it is very evident that the pilot's attention will be fully taken up by the special control of the power plant. Future developments should, therefore, be directed primarily to simplifying the service and eliminating all sources of error by an extensive use of automatic controls such as, for instance, are provided by the Junkers V.S. airscrew, or the blower speed gear drive which has been described in this article. Efforts have recently been made to group certain control levers into common housings; this idea might also be applied to levers which are mainly used in the high-speed dive.

SUMMARY.

The special influences to which the engine is subjected in the high-speed dive, have been described in these pages as well as the means adopted by German scientists and engineers in meeting the special conditions of strength and working behaviour imposed on the engine. The high-speed dive which was originally a gamble with death, can now be carried out with a very great measure of safety.

In this connection, the closest co-operation between the engineer and aircraft designer is bound to be of the utmost value since the special loads imposed on an aircraft during a dive affect every part of the structure and every instrument. Everything must therefore be designed to stand this extreme test. Specially good results are to be expected when the problem of the dive-bomber is handled by a firm such as Junkers which turn out not only aircraft, engines and airscrews of their own design, but also auxiliary equipment such as control and injection gear. The final result is the outcome of indefatigable research which, starting more than ten years ago was in a position to take up immediately the special engine problems connected with high-speed dives and find a successful solution.

We can be assured that on the basis of experience gained, it will be possible for the German aircraft industry to maintain also in the field the lead over our opponents.

REVIEWS.

FOUNDATIONS OF ASTRONOMY.

By W. M. Smart. Longmans, Green and Co. 1942. 16/-.

This excellent book is written by a former Instructor Lieutenant in the Royal Navy, now Regius Professor of Astronomy in the University of Glasgow.

Using elementary mathematics only, the author has succeeded in presenting the basic principles of astronomy in a comprehensive manner. With not more than simple spherical trigonometry, the solar system, the law of gravitation, the stars, the stellar motions, etc., are described in a style that is commendably free from the would-be pictorial writing so often found in " popular " books. Instead, it gives the solid foundations of astronomy, leaving the reader to draw his own inspiration from the nature of the subject. And it is indeed an inspiration, when men like the Astronomer Royal, Dr. H. Spencer Jones, devote ten years of patient work to the investigation of the solar parallax. By including the final value of this work on the solar parallax, the book is brought right up to date.

Summing up, the book can be thoroughly recommended to university students, to young men in the R.A.F. and naval services who are required to have some knowledge of Astronomy in its application to Navigation. It is provided with numerous examples of practical interest, to which answers are given at the end.

The inclusion of a star map and of some eclipse photographs would greatly add to the value of this book, which is likely to become a standard introduction to astronomy.

THE MODERN DIESEL.

(Sixth edition.) Iliffe and Sons, Ltd. 1941. 5/-.

This is the sixth edition of a handbook which was first published in 1930. In the last twelve years the Diesel engine has steadily been coming to the fore and for rail and road transport it has reached a position of great importance. The outbreak of war has delayed a similar development for aircraft engines, one which will certainly come when the war is over, unless some new form of power is developed. There is still considerable research and development work to be carried out, when the prospects are bright enough to make sure such work will be put in hand.

In this, the sixth edition, considerable revision has been made to bring the subject matter as up to date as possible. The handbook covers concisely and clearly the C.I. cycle, from injection systems, cylinder design, heavy oil fuel, road, rail, marine and aircraft Diesels. The fact that it is now in its sixth edition is in itself a tribute to the excellent work of its editors.

THE BOOK OF THE W.A.A.F.

The Amalgamated Press, Ltd. 1/3.

This book is modelled upon a previous work. " The A.B.C. of the R.A.F." which has already proved its value.

The W.A.A.F. is a necessary and integral part of the R.A.F. Every woman who serves in it releases a man for other duties; every woman who serves in it belongs to the Armed Forces of the Crown; and every woman who serves in it shares the same dangers and carries out the same duties as the Royal Air Force with the exception of serving in any air crew.

Here, in clear language, is given full particulars of the great service, the training and pay, the trades the airwoman can learn and the daily life and recreation. Some may think that in the W.A.A.F. there is not a great variety of things to do. In this book over 50 different trades are listed, a variety which gives any woman entering the W.A.A.F. one which is greater than she can normally get in peace time occupations. She has the advantage, too, of learning a trade under pleasant conditions and being looked after while she is doing it. The photographs on pages 13-19 show how pleasant these conditions can be.

This is an excellent book on every aspect of life in the W.A.A.F and can be thoroughly recommended to all those who are about to join and to all those who are now in it.

THE ROYAL AIR FORCE IN THE WORLD WAR.

Captain N. MacMillan, M.C., A.F.C. Vol. I. 1919-1940. G. G. Harrap and Co., Ltd. 1942. 10/6 net.

It will be some years before the full story of the Royal Air Force can or may, indeed, be told, but here is an excellent beginning by one who knows what he is writing about better than most men. Here is the pitiful story of failure of every government in the country between 1919 and 1938 to realise the vital use of the air arm. Here is the magnificent story of R.A.F. pilots going into action with inadequate machines and improvised organisation, the story of " too little and too late." Never, in the history of the world, have so few had the governing of a great empire and endangered the lives of so many by their gross incompetence. Every expert in the country warned government after government of the situation, to have their reports filed away as so much waste paper.

Captain MacMillan presents the facts without comment. It is for the reader to draw his own conclusions. Here is the story of the slow awakening to the German menace, the inadequate support to the aircraft industry, the procrastinating madness of the civil service machinery.

Then came the outbreak of war, the pamphlet dropping age, the battle of France and the campaign in Norway, and the final retreat from the Continent by the Air Force.

" In Norway the Allies first felt the effect of superior air power. . . . It was seldom that the Royal Air Force could muster more than a hundred aircraft all told for counter action to the thousand which the Germans employed in Norway," says the author, and adds " All the brilliant courage of the Royal Air Force could not overcome the tremendous handicap imposed upon their service by a generation whose supine folly was a vain hope of preserving peace without adequate arms in a fast re-arming world."

This is a book to read and re-read, to keep and digest. One looks forward to the succeeding volumes to obtain a connected account of that brilliant courage which will be the saviour of " this blessed plot, this England."

THE PRINCIPLES OF AIRCRAFT STRESSING.

W. L. Moore, B.Sc. Charles Griffin and Co. 1941. 18/-.

The growth of the aircraft engineering industry has brought about an increasing demand for textbooks. Unfortunately, in its wake, and under the urgent demands of war, there has also come into existence a demand for short cuts to the obtaining of just that amount of engineering knowledge which is just sufficient to scrape through. Everywhere short wartime courses have sprung up, and books are being produced which are aimed at satisfying the minimum demands of knowledge.

The book under review has been specially written for those draughtsmen from other branches of engineering who have drifted into the aircraft industry, and also for aircraft draughtsmen generally.

The author has made the assumption that users of the book will have a certain knowledge of mechanics, dynamics, elementary strength of materials and elementary calculus. What that certain knowledge is, however, is left vague. One feels that anyone who has sufficient knowledge to make use of the book would not want it, and those who have not the knowledge will find much in the book difficult to follow. It can be a very useful book, but on the other hand it can be a very dangerous one. For simple straightforward stressing under supervision of one who has been thoroughly trained in fundamental principles the book can be of use.

"The Principles of Aircraft Stressing" has the great merit of giving many practical worked out examples "supplemented by what should be ample descriptive matter," to quote the author's preface. If that had been the case, if the "ample descriptive matter" had been three times the length it is, if the fundamental theory involved had been fully and carefully explained, this book would have been just the kind of book that is wanted.

One wishes, for example, that the solution of the problems of thin-web beams and the differential bending of two-spar stressed skin wings were as simple as would appear from the author's exposition.

For the sake of the examples alone this book has its value. Used with judgment and care it is, indeed, a book which can be recommended. But it is not one to be recommended to teach any student the fundamental principles involved in stressing aircraft.

With the experience of the war behind him Mr. Moore will have an opportunity of writing a textbook of considerably greater volume in which his many excellent examples can back up his exposition of the fundamental principles which must be laid down clearly and firmly to all students who ultimately wish to play their part in the design of aircraft. It is to be hoped that Mr. Moore will write such a book.

AIR POWER AND CIVILISATION.

M. J. B. Davy, F.R.Ae.S. George Allen and Unwin, Ltd. 1941. 8/6 net.

The first three chapters of this book are familiar history of the birth of flight, though familiar history written in a pleasing way by one who knows how to write. One is more concerned with the remaining chapters on the reaction of the world to the coming of the aeroplane, the aeroplane as an instrument of destruction, the social consequences of its survival, and its control.

The author ends his chapter on the reaction to the new invention with the words: "This, then, is the main reaction to the new invention—that the peoples of the world will rise up and destroy it unless their rulers can plan more wisely for the future."

The reviewer doubts very much whether the people of the world, however exasperated, will ever rise up and destroy a weapon which may give them mastery at some time or other. But this is by the way. What has always puzzled the reviewer is, why is the aeroplane picked upon as some peculiarly ruthless weapon of warfare different and more deadly than any other kind of weapon? How does it differ in principle from the long range gun? What does it do that has not been done in war throughout the centuries? Blow up cities? Set fire to them? Kill women and children? Wipe out civilian populations? Use gas? All these things have been done in the past without the use of any aeroplane. It is frankly just ridiculous to say that the aeroplane has introduced some new factor into war which will make war so terrible that the peoples of the world will not put up with it. As long as they will put up with war in any form they will put up with the aeroplane or any other weapon of war. What is wanted is a change of heart among the people themselves to avail themselves of advances in science in their applications to the arts of peace.

The author admits in his chapter on the Aeroplane as an Instrument of Destruction that bombing, however savage, of civilian communities does not produce a decisive moral effect. "It appears easy to irritate, but almost impossible to demoralise a civilised community by bombing homes and families." The author is cautious enough to add that this opinion is based on the scale of bombardment so far experienced.

On page 172 the author, in his consideration of the possibility of controlling air power by international agreement, states among the opinions relating to air power "that the immediate cause of war is an excess of armaments, and in particular a lack of balance in their distribution; therefore weapons should be limited and equalised by international agreement, and air power, being the least humane, should be progressively reduced."

It is high time this fatuous attitude of so many people that "air power, being the least humane," should be stamped upon ruthlessly, without any equivocation whatever, and in as clear language as possible.

Before the advent of air power the same thing was being said about the submarine; the same thing was said about the use of gas in the war of 1914-1918; and the same thing will be said, one does not doubt, about some new destructive use of science in the years to come.

One of the real steps formed in civilised progress is the obtaining of freedom in as wide a sense as possible consistent with the amenities of the rest of the population. Freedom of speech and freedom of religion are two of the main planks in any civilised platform. The reviewer would like to add freedom of movement, the abolition of all national barriers, and with it freedom of the skies. If any aeroplane were allowed to fly anywhere it liked, within the necessary safety rules of the skyways, much of the so-called terror of the skies would have gone. Abolish any areas over which aircraft must not fly, on the score of secrecy, abolish the right of any nation to own the sky above them, and some of the problems may be solved.

Even that will not prevent a nation building aircraft factories underground, invisible from the sky, and piling up a huge air force in reserve, but that air force has got to learn to fly and to do that it must go up in the sky, and must risk being seen by peaceful touring aircraft. Freedom of the skies would increase the difficulties of an air force preparing for war.

That war will ever be abolished is unbelievable, from the very nature of life itself. That it can be made more and more difficult is a possibility.

"Air Power and Civilisation" is worth reading because it is a considered point of view of one who has had much to do with aviation over many years. Whether the readers will agree with it or not, however, depends upon their fundamental outlook on "air power being the least humane" of war weapons.